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Resource Recovery

INNOVATIVE REFUSE COLLECTION
MUNICIPALITY OF WINDSOR

B. I. Boyko

A. J. Burnham

Ontario Ministry of the Environment
Waste Management Branch

August, 1978

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ACKNOWLEDGMENT

The authors would like to thank staff of the Public Works Department, Municipality of Windsor, for their co-operation throughout this study. The assistance of Messrs. Walt Coulter, Ken Lemire, and Jim Steele, all of this Division, is particularly acknowledged.

SUMMARY

A joint study using two different innovative refuse collection systems was carried out by the Municipality of Windsor and the Ontario Ministry of the Environment. The project involved a one-man mechanical collection vehicle servicing 0.34 m^3 containers as well as large 1.13 m^3 containers. This vehicle was capable of picking up, dumping, and returning the specially designed refuse containers to curbside. The other innovative collection system studied involved the use of 0.30 m^3 containers and mechanized tipping devices attached to conventional rear-loading packers. The special containers for this system were wheeled to the rear of the collection vehicle, fastened to the hydraulic tipping device, mechanically raised to empty the container, and then lowered back to the road surface. The container was then disengaged from the tipping device and wheeled to curbside.

Productivity of the innovative collection systems as well as that of two control routes was measured using the Municipality's existing management accounting system. Time studies were also carried out to assess productivity of the various systems.

Householder attitude surveys were conducted before, during, and after the study period.

For the collection conditions and existing systems serving the Municipality of Windsor, the study on innovative refuse collection techniques concluded that:

1. Collection productivity was significantly increased by using mechanical collection as opposed to conventional collection using rear-loading packers and two-man crews.
2. The mechanized tipping system did not yield any improvement in collection productivity, as measured by any parameter.
3. Widespread implementation of mechanical collection requires significant capital expenditures, mainly for the provision of collection containers to householders.

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INTRODUCTION

Refuse collection in the past was considered a routine and not unduly expensive municipal operation. Precise collection costs were usually hidden in overall waste management costs and thus not readily available. However, in a labour-intensive operation such as refuse collection, the continuing inflationary increase in wages has an ever-increasing impact on municipal solid waste management budgets. Manual collection of refuse is also frequently associated with higher rates of illness and injury as compared with other municipal operations; these factors also increase the cost of solid waste collection. The aesthetics of refuse collection, or more specifically of refuse prior to collection, are probably the most visible problems to the general public.

Mechanized refuse collection must be considered an alternative to existing collection practices if any effort is to be attempted to reduce or eliminate the above-mentioned problems.

In 1975, the Municipality of Windsor approached the Ministry of the Environment seeking funding assistance for a pilot project on innovative refuse collection. In addition to anticipating improvements in the problem areas already mentioned, additional information was required to ensure that mechanized collection systems were suitable in Canadian conditions, to assess possible problems with such systems, and to determine accurate costs of these systems. The Ministry of the Environment considered participation in

such a study to ensure that waste management in this Province becomes more efficient with the proper assessment and utilization of advanced technology. An agreement was subsequently reached for a joint project involving mechanized refuse collection.

The joint pilot project involved the use of two different types of mechanized collection systems in three selected full scale collection routes within the City of Windsor. Two of the routes featuring predominantly detached homes utilized two types of wheeled containers (0.34 m^3 and 0.30 m^3 capacities). The third used large 1.13 m^3 containers located in a condominium development. Under terms of the Agreement, the Province provided the necessary funding to purchase all the containers and mechanical collection devices required. The Municipality provided collection vehicles, collection labour, and repair and maintenance services.

The information collected during the study consisted of:

a. collection productivity data,

b. operating and maintenance costs,

c. householder attitude surveys before, during and after the study period, and

d. time and motion studies on the various collection systems.

BACKGROUND

A general review of the available literature on mechanized collection systems indicates that frequently considerable attention is paid to a municipality about to undertake some form of mechanized collection, but rarely are detailed cost data provided[1, 2, 3, 4]. In some cases, the significant savings attributed to mechanized collection result primarily from a reduction in collection frequency, or a shift from backyard to curbside collection[1, 2]. A comprehensive review of alternative methods of mechanized collection is presented in, "Solid Waste Collection Practice", prepared by the American Public Works Association[5].

In assessing the costs of refuse collection, some commonly used productivity parameters are:

- tonnes collected per man per hour,
- costs per tonne collected,
- costs per stop serviced, and
- number of stops per man per hour.

Parameters such as these have been reviewed for various collection practices and are presented elsewhere[5, 6]. However, in reviewing collection costs, APWA's "Solid Waste Collection Practice"[5] notes, 'differences exist from community to community and this makes cost comparisons of collection systems difficult to make'.

In response to inflationary increases in labour and equipment operating costs, the Municipality of Windsor had undertaken numerous efforts to improve solid waste collection productivity. Some of these measures included a reduction in collection frequency,

a reduction in collection crew size, construction of a centrally-located waste transfer station, and the design of more efficient refuse collection routes. In addition, various types of collection vehicles such as a one-man packer, a high-density packer, and a satellite collection vehicle had been used on a trial basis to assess collection efficiencies.

Notwithstanding these efforts, the Municipality investigated other innovative refuse collection methods to further reduce or at least maintain present operating costs, to reduce personnel injuries, and to improve the aesthetics of refuse collection for both collection personnel and the general public.

A field trip was made to investigate both mechanized tipping and mechanical collection systems. The Municipality then formally requested financial assistance from the Ministry of the Environment to aid in conducting pilot studies on innovative refuse collection techniques. In April, 1976, an agreement between the Municipality of Windsor and the Ministry of the Environment was signed. This agreement called for a joint study with the Ministry providing the necessary equipment for the study, at a cost not to exceed $100 000, and the Municipality assuming responsibility for the day-to-day operation of the collection system and for maintenance of the equipment purchased for the study. All pertinent records for the mechanized collection system were to be maintained by the Municipality and the Ministry was to be responsible for the final report on the project. The study was to continue for a minimum of one year unless termination was considered mutually advisable. Upon completion, all equipment purchased by the Ministry would be returned to

the Ministry.

When establishing the study programme, it was decided to establish a test route using mechanized tipping in addition to test routes involving mechanical collection. Mechanical collection routes used both multiple dwelling containers as well as smaller individual household containers. All equipment for the study was purchased on a tender basis.

STUDY DEFINITION

The study of innovative refuse collection looked at both the mechanical collection as well as mechanized tipping approaches. Three collection routes within the Municipality were chosen as trial study areas. The chosen routes were considered to be representative areas featuring predominantly single family dwellings with one exception as noted below. In addition to historical collection information being available, these routes also covered a broad range of physical aspects, e.g. curbs, roadside ditches, free and limited access.

For the mechanized tipping study, the 442 households in Route 526 (Figure 1) were provided with wheeled carts of 0.30 m^3 capacity. In addition, hydraulic tipping devices were installed on rear-loading packers serving this particular route.

In selecting routes to evaluate mechanical collection, it was decided to assess the efficiency of such a collection system on two routes. One route featured mostly single family containers (0.34 m^3), and the other route contained primarily large containers (1.13 m^3) designed to service more than one family. In U.S. applications, the large multi-family containers have traditionally been used for alley collection with three to four households sharing the same container. However, alley collection is relatively rare in the Province of Ontario, and, where alleys exist, they are usually too narrow to accommodate a mechanical collection vehicle. Consequently it was decided to assess the use of large multi-family containers in a medium density condominium townhouse development.

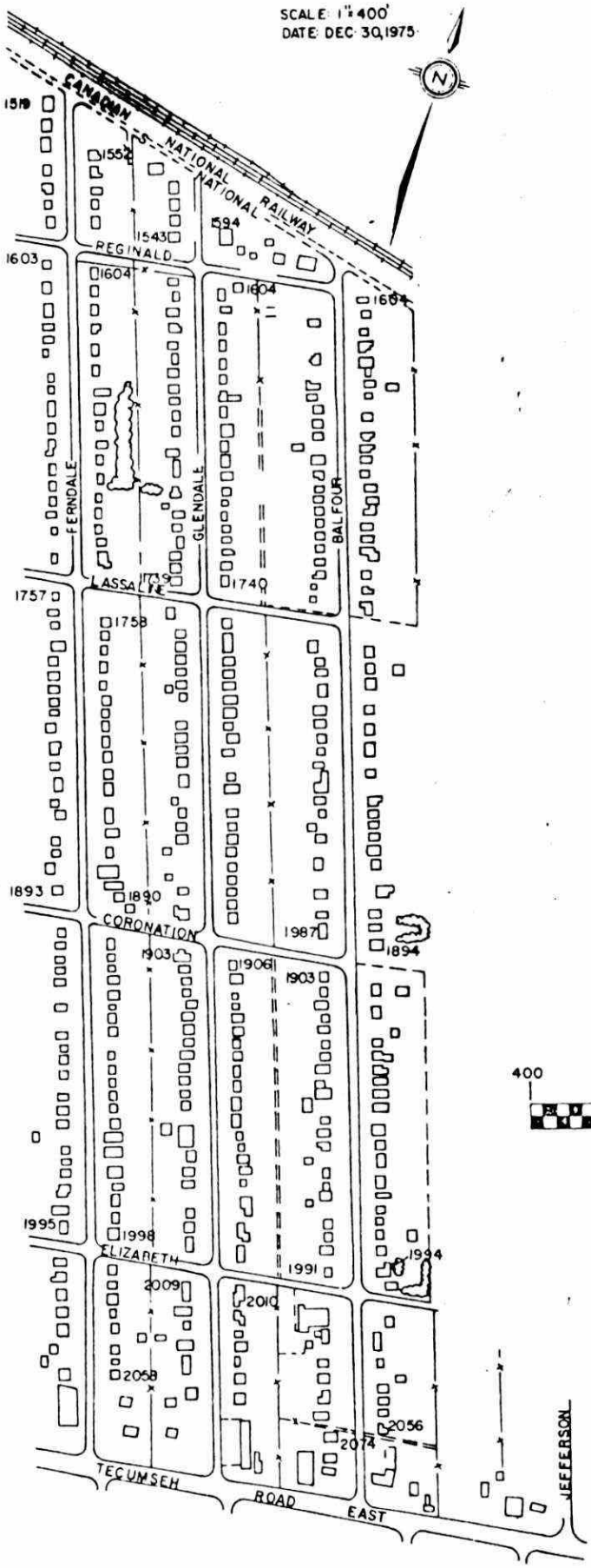


FIGURE 1

MECHANIZED TIPPING
Route 526

At the time, this development was served by manual collection from several enclosed garbage repositories. The large containers were also used to service several light commercial operations located on these collection routes.

Mechanical collection was then studied on two routes: Route 521 (Figure 2) having 534 households and three commercial pickups, and Route 523 having 294 households in total and being serviced by 154 small containers and 44 large containers serving a condominium subdivision. The 154 small containers were subsequently added to Route 523, a half-day route, in order to provide adequate workload for that particular route. The large container, 1.13 m^3 capacity, was not mobile and thus containers were placed along right of ways within the condominium development. The containers were placed in multiples of two to five, depending on the proximity of the users.

All containers used in the study had an instruction decal affixed to the underside of the container lid. The mechanical collection containers also had "NO PARKING", and "This side to curb" decals on the container curbside, since proper positioning of the container at the curb was of paramount importance.

Prior to the actual start of the study on October 5, 1976, a survey was undertaken to assess the public attitude in the study areas. This survey included questions on the present refuse collection system and refuse collection in general. The appropriate containers along with an explanatory brochure were then distributed by Municipality staff. The brochure noted the study duration of one year. The public information brochure and letters are shown in Appendix D.

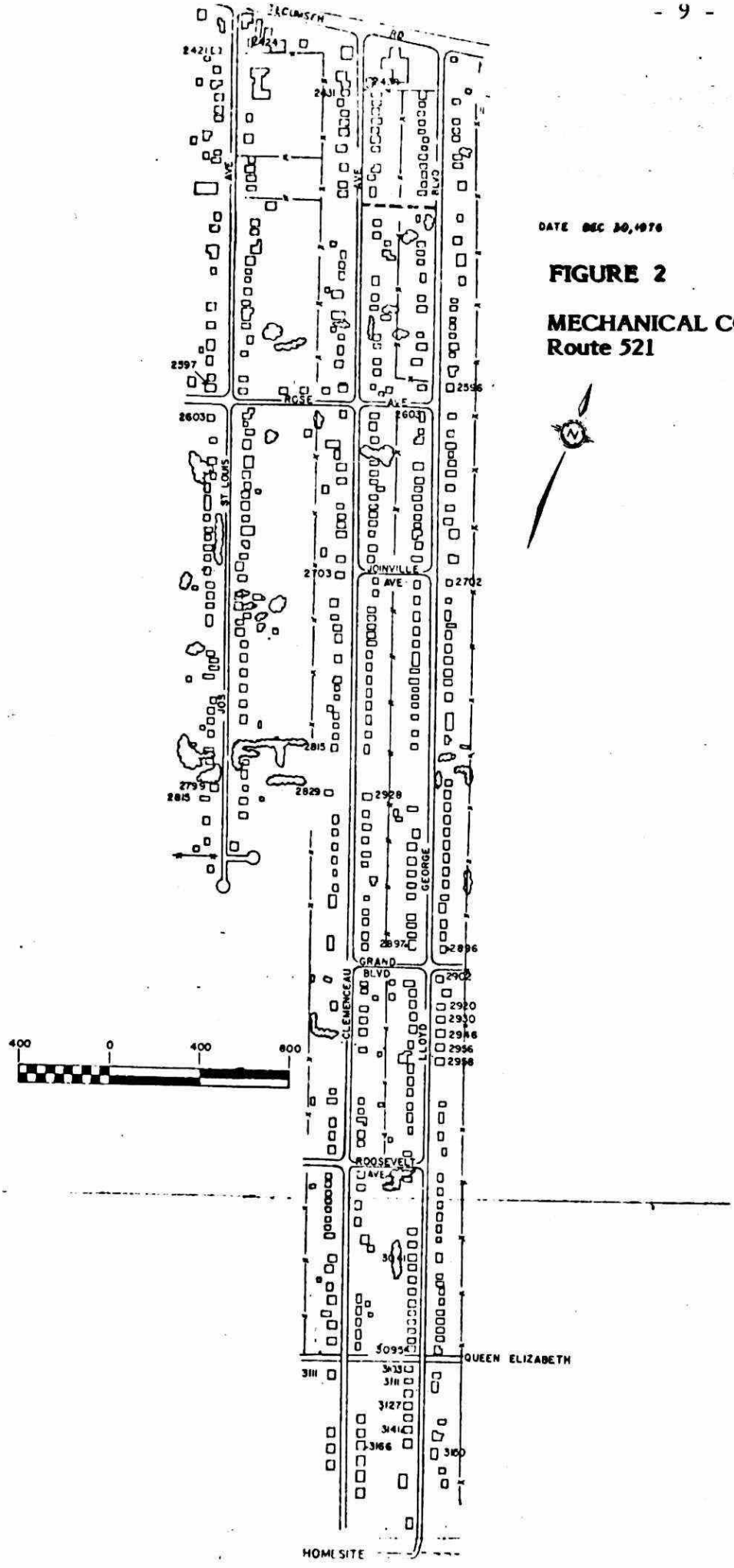


FIGURE 2

MECHANICAL COLLECTION
Route 521

Householders were also advised that all refuse must be set out in the containers provided and that no other containers would be picked up. Bulky refuse (furniture, appliances, etc.) would be picked up on the same collection day by a special bulky wastes collection crew. After approximately six months of operation, an additional attitude survey was taken in the study areas. A third survey was conducted approximately six weeks after completion of the innovative refuse collection study.

Although collection on all study routes began on October 5, 1976, termination dates varied. The mechanical collection study (Route 523) serving the condominium development ended prematurely on February 17, 1977, due to resident dissatisfaction. This discontent was largely aesthetic in nature. The large number of containers required had to be set in highly visible locations to allow collection vehicle access. In addition, the containers were blown over frequently and would often roll onto driveways, lawns, and parking lots.

At this time, the remainder of Route 523 (0.34 m^3 containers only) was incorporated into Route 521.

The Route 526 study, mechanized tipping, utilized a three-man crew on July 13 and 20, 1977, to assess whether productivity could be increased. Beginning September 19, 1977, collection was carried out on a 10-hour, 4-day week. The overall Route 526 study was terminated on October 27, 1977.

Route 521, featuring mechanical collection for individual households, shifted to a 10-hour, 4-day week on September 19, 1977, as well and terminated on October 27, 1977.

The shift to a 4-day work week had been planned by the Municipality and was not institigated by the studies on innovative refuse collection.

Collection data were also obtained for two additional routes, serving as controls. These routes were served by normal manual collection and were geographically located adjacent to two of the study routes, i.e. Route 433 served as the control for Route 526, and Route 442 for Route 521.

Table 1 summarizes the collection routes investigated.

TABLE 1

INNOVATIVE REFUSE COLLECTION - ROUTES STUDIED

Route	System	No. of Households	No. of Containers
521	Mechanical collection	534	544 - 0.34m^3 containers 9 - 1.13 m containers
523	Mechanical collection	294	154 - 0.34 m^3 containers 44 - 1.13 m containers
526	Mechanized tipping	442	452 - 0.30 m^3 containers
433	Manual Collection	460	
442	Manual Collection	500	

EQUIPMENT

Mechanical Collection

The mechanical collection system studied consisted of two components:

1. A mechanical collection arm supplied by Litter-Lift Systems, Inc., through Fiberglas Specialists Inc., 102 East Pioneer, Phoenix, Arizona, and
2. Collection containers supplied by Hollowform Inc., 6345 Variel Avenue, Woodland Hills, California, 91364.

This system featured a mechanical arm (Figures 3, 4, 5, and 6) capable of grasping, lifting, dumping, and returning to the curb an appropriately designed collection container. All of these operations were carried out hydraulically with a total cycle time of approximately 20 seconds. The system had a maximum lift capability of 680 kg.

The unit was mounted on a side-loading, refuse vehicle, Shu-Pak Auto Model 103 on an International chassis. The hydraulic controls for the mechanical arm were located in the packer cab, below the right-hand drive controls. Eleven inches of ground clearance remained with the equipment installed. The hydraulic power source was capable of 10 MPa at 56 lpm with all cylinders being 6.35 cm bore. No hydraulic motors or drive sprockets were used.

Grips of spring steel lined with vulcanized rubber made a 270 degree contact with the container (1935 cm^2 surface contact on

FIGURE 3

MECHANICAL COLLECTION

LOWERING MECHANICAL ARM

FIGURE 4

MECHANICAL COLLECTION

LIFTING 0.34 m^3 CONTAINER

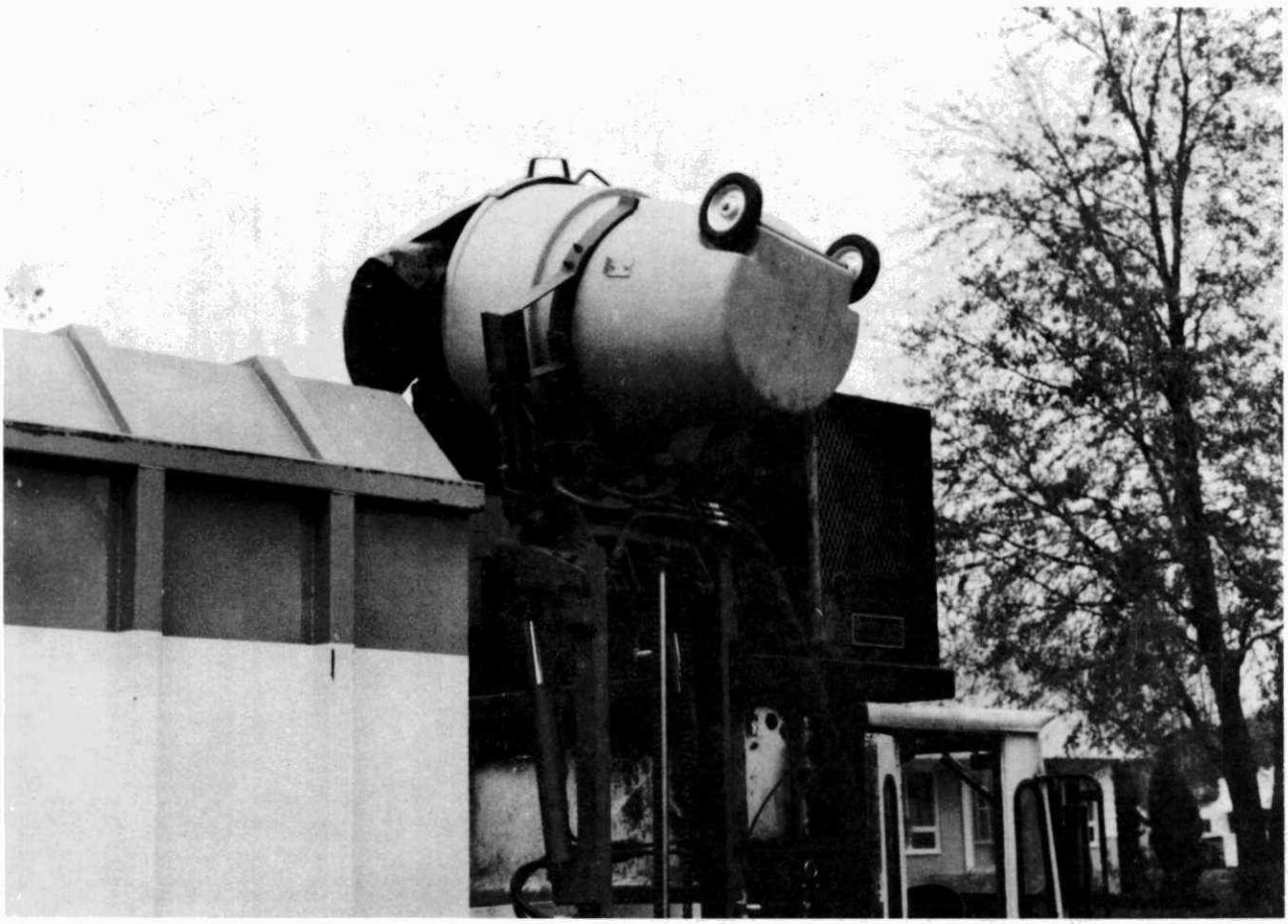


FIGURE 5

MECHANICAL COLLECTION

DUMPING 0.34 m^3 CONTAINER

FIGURE 6

MECHANICAL COLLECTION

LIFTING 1.13 m^3 CONTAINER

1.13 m^3 container and 1160 cm^2 surface contact on 0.34 m^3 container). Grips could be changed in one minute without the use of tools.

As indicated earlier, two sizes of containers were used for the mechanical collection system, 0.34 and 1.13 m^3 capacities respectively. These containers, manufactured by Hollowform Inc., were produced from high density cross linked polyethylene and featured permanently attached hinged lids.

Mechanized Tipping

The mechanized tipping system featured a 0.30 m^3 wheeled container capable of being grasped by a hydraulic tipping unit installed on a rear- or side-loading collection vehicle (Figure 7). The wheeled containers were manufactured by Rubbermaid, Inc., 2562 Stanfield Road, Mississauga, Ontario L4Y 1S5.

For the study, two tipping units were mounted on a Heil Model Mark III, 15 m^3 rear-loading packer and one additional tipping unit was mounted on a similar backup collection vehicle. The existing hydraulic system on the collection vehicle was used for operating the lift units; controls for raising and lowering the collection containers were mounted on each side of the vehicle. The lifting units allowed ample ground clearance when in the down position and did not interfere with normal truck operations. Once the container was fastened to the tipping device, the complete dumping cycle required approximately 15 seconds.

The 0.30 m^3 collection container, approximately 80 cm long, 70 cm wide, and 110 cm high was molded from dark green

FIGURE 7

MECHANIZED TIPPING TIPPING OF 0.30 m^3 CONTAINER

polyethylene with the lid being loosely attached via a pressure fit. As with the mechanized collection system, the hinged lid on the collection container remained fastened at all times, opening under the force of refuse being dumped and closing upon completion of the cycle.

The maximum recommended load for the mechanized tipping unit was 90 kg, with the container itself weighing 18 kg.

STUDY RESULTS AND DISCUSSION

The results obtained from this one-year pilot study on innovative refuse collection techniques fall into four broad categories:

1. conventional collection and productivity parameters, e.g. tonnes collected per man hour;
2. time study data on collection activities;
3. overall system costs including equipment acquisition and maintenance; and
4. customer attitude surveys.

The Municipality of Windsor has a well established and thorough management accounting system for identifying solid waste collection costs. Collection productivity data are compiled routinely and bi-weekly reports are prepared indicating both current and year-to-date productivity. A typical printout for this information is shown in Table 2, "Residential Collection Statistical Analysis", as prepared by the Municipality. In Table 2, the man hour data shown reflect gross man hour allocations to a particular collection route, including any overtime expended. However, should a collection crew complete its route in less than a normal working day, and if the crew is re-assigned to another duty, then the man hours allocation is less than a normal working day. The overall man hours include travel time to the route, collection time, travel time to and from the transfer station, allotted break time, etc. In the event of a mechanical breakdown, crew downtime was not included as man hours expended on that collection route.

TABLE 2

RESIDENTIAL COLLECTION STATISTICAL ANALYSIS - TYPICAL PRINTOUT *

Period Ending 10/02/76(A) Area 3(B) Foreman: McGregor

Route Number	Day	Man/Hours Cur	Man/Hours YTD	Tons Cur	Tons YTD	Cost(C)	Stops(D)	M/H(E) Stop	LBS.(F) Stop	M/H/Ton(G) Cur	M/H/Ton(G) YTD	Cost/Stop Cur	Cost/Stop YTD	Cost/Ton Cur	Cost/Ton YTD
316(H)	Monday	34.00	651.50	19.90	401.45	5712.38	410	.042	51	1.71	1.62	.36	.37	14.89	14.23
326	Tuesday	42.00	792.00	26.90	515.05	7031.66	532	.051	66	1.56	1.54	.34	.46	13.61	13.65
336	Wednesday	36.00	706.00	22.20	449.00	6227.90	475	.039	49	1.62	1.57	.33	.35	14.10	13.87
346	Thursday	38.00	662.50	24.40	398.30	5772.88	550	.030	36	1.56	1.66	.30	.26	13.57	14.49
356	Friday	36.00	647.00	20.80	392.30	5990.48	400	.038	46	1.73	1.65	.39	.35	15.05	15.27
	Total :	186.00	3459.00	114.20	2156.10	30735.30	2367								
Crew Avg.(I)		37.20	691.80	22.84	431.22	6147.06	473	.040	50	1.64	1.61	.34	.34	14.24	14.30
Frmn Avg.(J)		35.77	676.17	23.02	425.95	6001.39	494	.037	46	1.56	1.60	.32	.33	13.64	14.15
Div. Avg.(K)		35.16	651.26	23.45	425.28	5867.14	509	.034	43	1.52	1.56	.30	.31	13.35	14.00

(A) Current Data for 2 weeks preceeding date. YTD (Year-to-date) data for full calendar year end on period date.

(B) Area of City Collected

(C) Includes all equipment and labour. No overhead included.

(D) Number of locations picked up once a week.

(E) YTD Average manhours per stop.

(F) YTD Average pounds per stop.

(G) Current and YTD manhours per ton

(H) Route Number: 3 - area of city 1 - day of week 6 - crew

(I) Crew's average.

(J) Foreman's Average for all his crews.

(K) Solid Waste Division average for all residential collection crews.

* Municipal records not converted to metric units at time of study.

The tonnage figures compiled are derived from collection vehicles weighing in at the transfer station and the use of a tare weight.

Cost allocations are derived from direct collection labour costs and equipment rental costs. Within the Municipality, a separate Division purchases and maintains all municipal vehicles, including refuse collection vehicles. An internal rental charge covering depreciation, maintenance, and operating costs is then made to the user Division. For this study, the rental rate for the side-loading vehicle was $14.00 per hour and $12.00 per hour for the rear-loading packer.

A. Collection and Productivity Parameters

The detailed productivity parameters as compiled by the Municipality of Windsor are presented for each collection route studied in Appendix A. In addition to the information on the innovative collection routes, productivity data is also presented for the two routes considered to be similar to the study routes and thus serving as 'Control' routes. For these control routes, as with other manual collection routes in the Municipality, two-man crews are used. Ideally, a route featuring a one-man side-loading packer would have served as a control for the mechanical collection system under study. Also included in Appendix A is a summary of productivity data covering all the collection activities of the Municipality's Solid Waste Division.

In Appendix A, the productivity data collected over the period October 3, 1976 to September 17, 1977 represents information obtained while the Solid Waste Division was working a forty-hour

TABLE 3

SUMMARY OF PRODUCTIVITY PARAMETERS

Parameter	Mechanical Collection Route 521	Mixed Mechanical Collection Route 523	Mechanized Tipping Route 526	Control Route 433	Control Route 442	Division Average
Man Hours						
Mean:	20.3	12.6	40.7	33.1	32.7	31.8
90% C.R.*	17.4-23.1	8.2-17.0	38.7-42.7	31.8-34.4	29.9-35.5	30.5-33.1
Tonnes						
Mean:	23.76	9.70	18.58	17.80	18.64	18.85
90% C.R.*	21.44-26.08	7.62-11.77	16.85-20.30	16.23-19.37	16.42-20.86	17.15-20.55
Costs						
Mean:	353.75	188.73	446.40	368.91	391.85	
90% C.R.*	318.24-389.26	128.56-248.90	416.43-476.36	339.68-398.13	338.07-445.63	
Man Hours/ Stop Mean:	0.019	0.021	0.046	0.036	0.033	0.035
90% C.R.*	0.016-0.022	0.014-0.029	0.044-0.048	0.035-0.037	0.030-0.035	0.034-0.036
Man Hours/ Ton Mean:	0.91	1.37	2.33	2.01	1.88	1.80
90% C.R.*	0.74-1.09	0.89-1.85	2.10-2.55	1.77-2.25	1.63-2.14	1.66-1.94
Cost/Stop						
Mean:	0.331	0.321	0.505	0.401	0.392	0.366
90% C.R.*	0.298-0.364	0.219-0.423	0.471-0.539	0.369-0.433	0.338-0.446	0.342-0.389
Cost/Ton						
Mean:	15.65	20.73	25.27	22.11	22.12	19.97
90% C.R.*	13.67-17.64	14.34-27.13	22.87-27.67	19.60-24.62	18.72-25.53	18.51-21.42

NOTES:
1. * 90% Confidence Range
2. All costs in dollars
3. All weights in metric tons

five-day week. In Tables 1 and 3, the last line of data covering the period September 18 to October 9, 1977 represents productivity information from a 10-hour, 4-day week collection schedule. These data (September 18 - October 29) were not included in the statistical analyses of the productivity parameter results. The cost per ton figures obtained for the 10-hour day indicate a 20 percent reduction in collection costs when compared to the mean cost per ton obtained over the entire study period. However, this improved efficiency is not substantiated by the cost per stop data which actually increased with the introduction of the 10-hour day. Increased tonnage collected during this fall period could account for this anomaly.

Although the productivity parameters presented in Appendix A are self explanatory, several comments are in order.

The apparent inconsistencies between man-hours and cost data within a particular table stem from two factors: the degree of overtime required affects the labour component of the total cost, and the labour and equipment chargeback rates were revised upward during the study.

In Tables 1 and 2, the high collection costs for the periods November 28 - December 11 and December 26 - January 8, 1977 were the result of breakdown in the collection equipment. For both of these periods refuse was collected manually. However, these high cost figures were included in the statistical evaluation of the data.

Summary data for each of the routes studied including the two "Control" routes and the overall division average is presented in Table 3. As noted in this table, the results are presented in terms of the 90 percent confidence limits for the parameter observed; the use

of such confidence limits allows ready evaluation and comparison of results of different routes.

An analysis of variance was carried out using the cost per tonne parameter for each of the routes studied. The results of this variance testing, carried out at the 95 percent probability level, indicated that:

- collection costs for the mechanized tipping were significantly greater than those for the mechanical collection,
- no difference was found between the two control routes and the Division average,
- no difference was found between the mechanized tipping and control results,
- collection costs for mechanical collection were significantly less than for the control routes.

In summary, the costs of collection, using the cost per ton parameter, for the mechanical collection routes were significantly less than those for either the mechanized tipping or control routes.

The mechanized tipping study utilized the same collection crew that serviced that particular route in the previous year. With mechnaized tipping, the mean collection productivity was 2.33 man-hours per ton compared to the previous year's productivity of 1.63 man-hours per ton.

Since the mechanized tipping costs were comparable to the control costs, it was anticipated that productivity would improve

if the mechnaized tipping route used a three-man crew collection crew. This was done for the period July 10 to 23, 1977. Although collection costs expressed as cost per ton were lower for this period as compared to the mean for the entire study, this was primarily the result of eliminating overtime rather than improved efficiency. The use of a three-man collection crew serving both sides of the street was considered somewhat hazardous and was discontinued after two weeks at the union's request.

It is interesting to compare gross collection man-hours as a function of tonnage collected. Figure 8 plots these data for the mechanical collection (Route 521), mechanized tipping (Route 526) and one of the controls (Route 442). For the mechanical collection, the labour requirement is relatively independent of tonnage collected. For the other two routes, the man hours increased somewhat with increasing tonnage collected. This indicates that, for mechanical collection, the labour requirement is independent of collected tonnage or that the route was significantly undersized. Figure 9, man-hours per stop vs tons collected, also supports this observation of the relative insensitivity of mechanical collection to tonnage collected.

When considering mechanical collection in Canada, the effect of cold weather operation on system performance is also of concern. Figure 10 illustrates the man-hours per stop vs time of study data for both the mechanized collection and control routes. Excluding the two major breakdown periods, not the result of cold weather operation, Figure 10 indicates no undue seasonal problems were encountered with the mechanical collection system. Although not shown, similar results were observed for the mechanized tipping system.

Figure 8

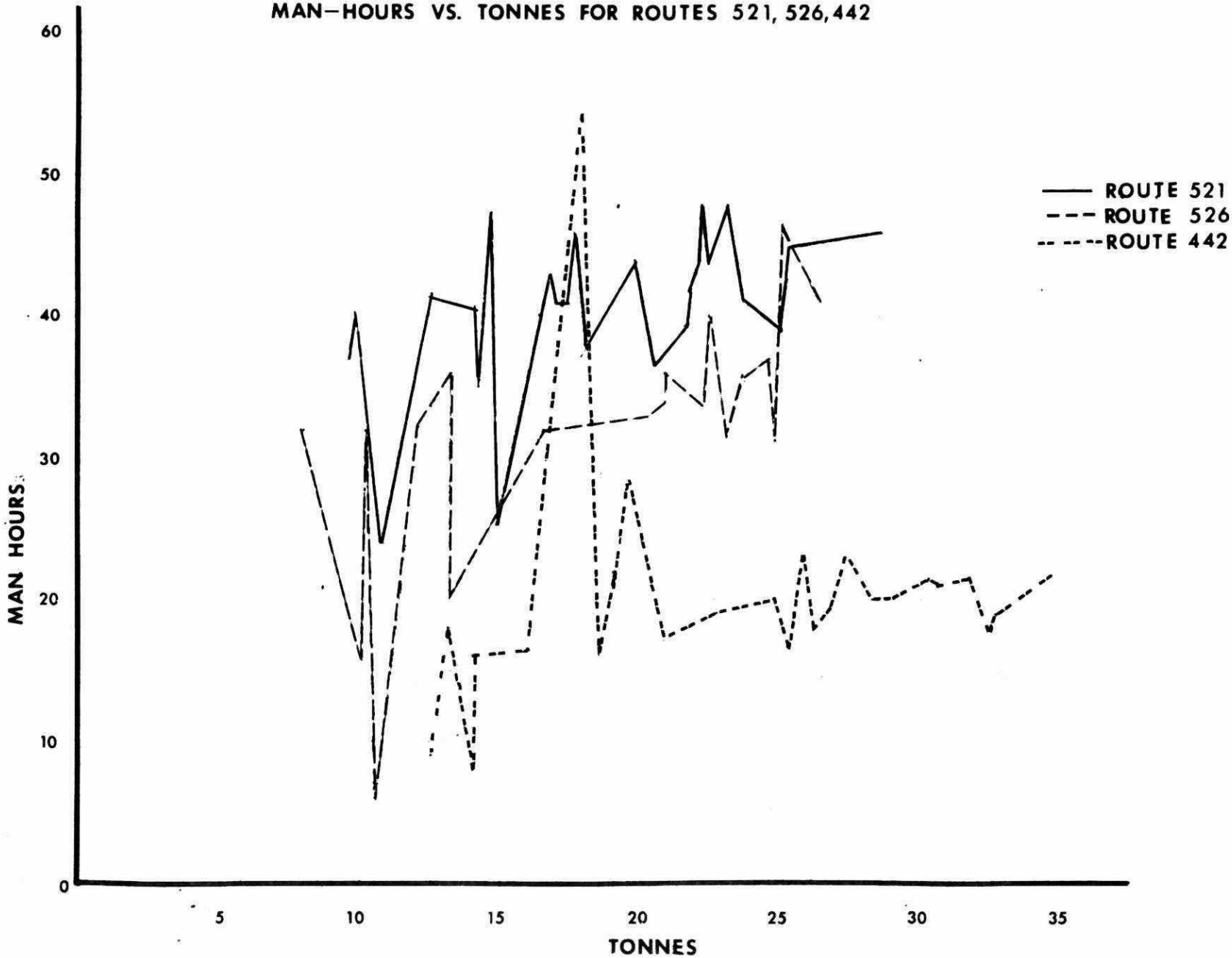

MAN—HOURS VS. TONNES FOR ROUTES 521, 526, 442
MAN HOURS
TONNES
0
10
20
30
40
50
60
5
10
15
20
25
30
35
ROUTE 521
ROUTE 526
ROUTE 442

Figure 9

MAN-HOURS/STOP VS. TONNES FOR ROUTES 521 & 442

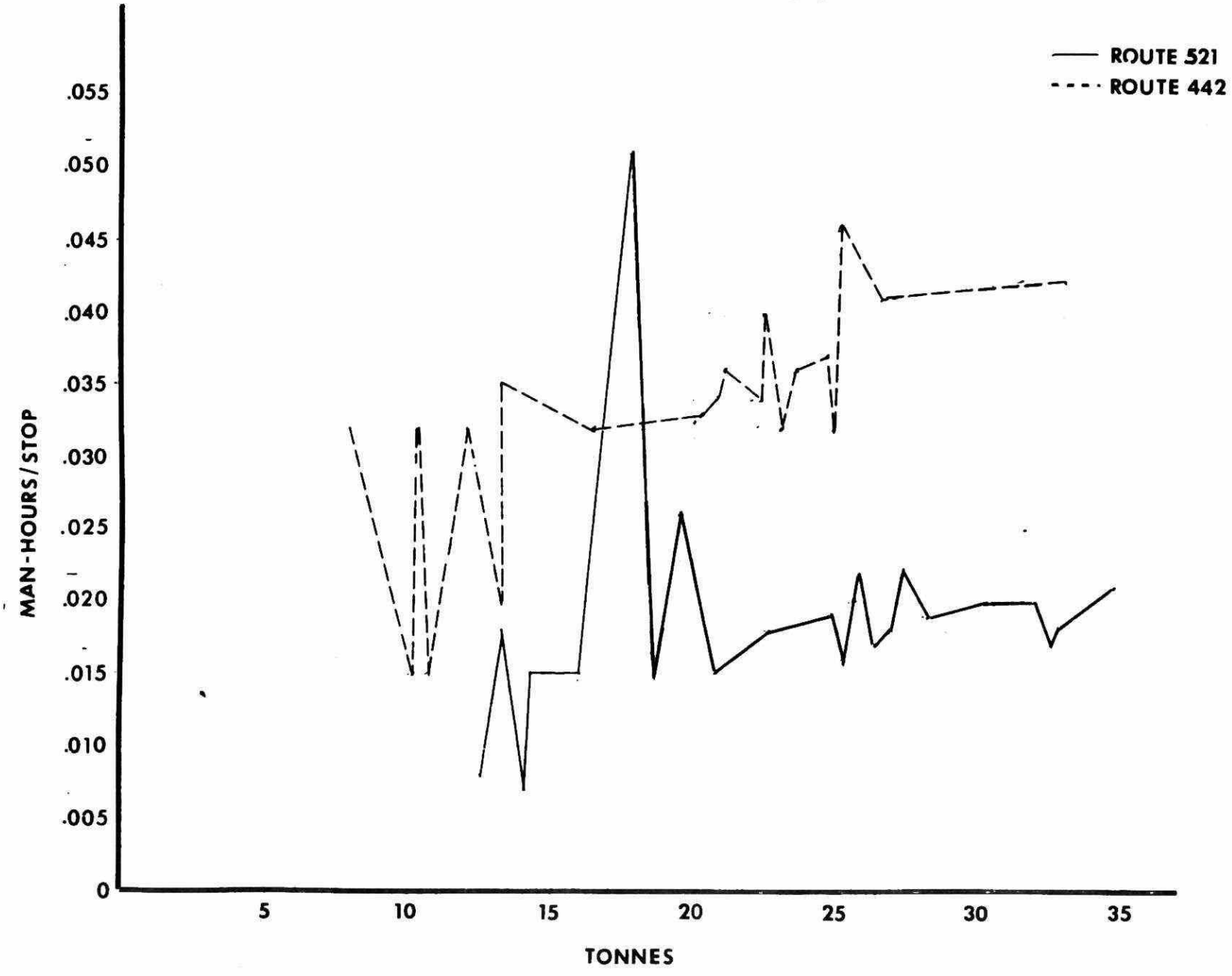
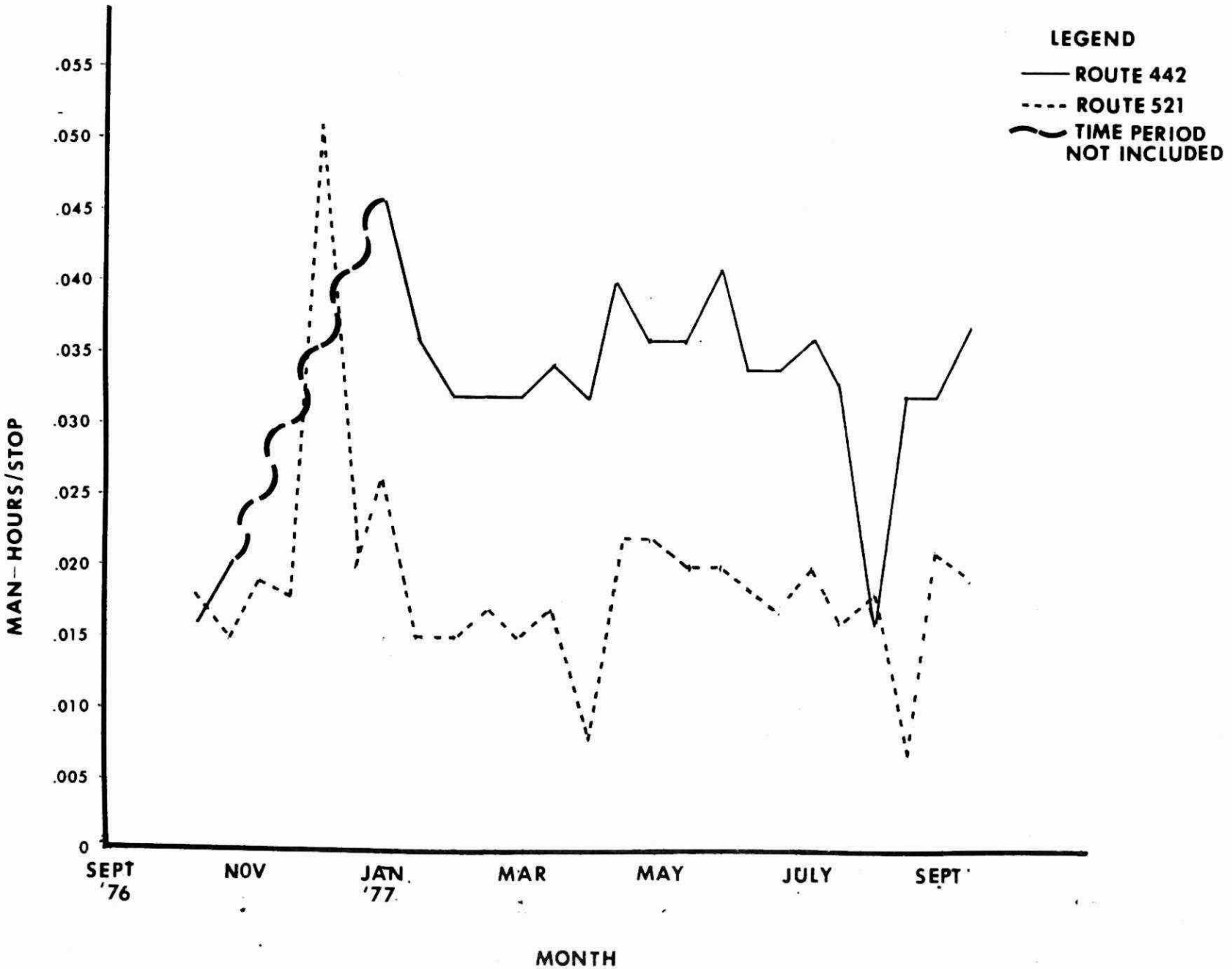


Figure 10

MAN-HOURS/STOP VS. MONTH FOR ROUTES 442 & 521



The data in Appendix A appear to indicate that productivity, expressed as man-hours per tonne, varies seasonally. However, Figure 11 illustrates that this apparent seasonal effect on productivity is merely the result of collection tonnage varying over the course of the year. Man-hour per tonne requirements should vary inversely to collected tonnage, within reasonable limits.

The foregoing discussion and conclusions reached are entirely dependent on the productivity parameters measured over the duration of this study. It must be recognized that, for any system, collection costs are a function of:

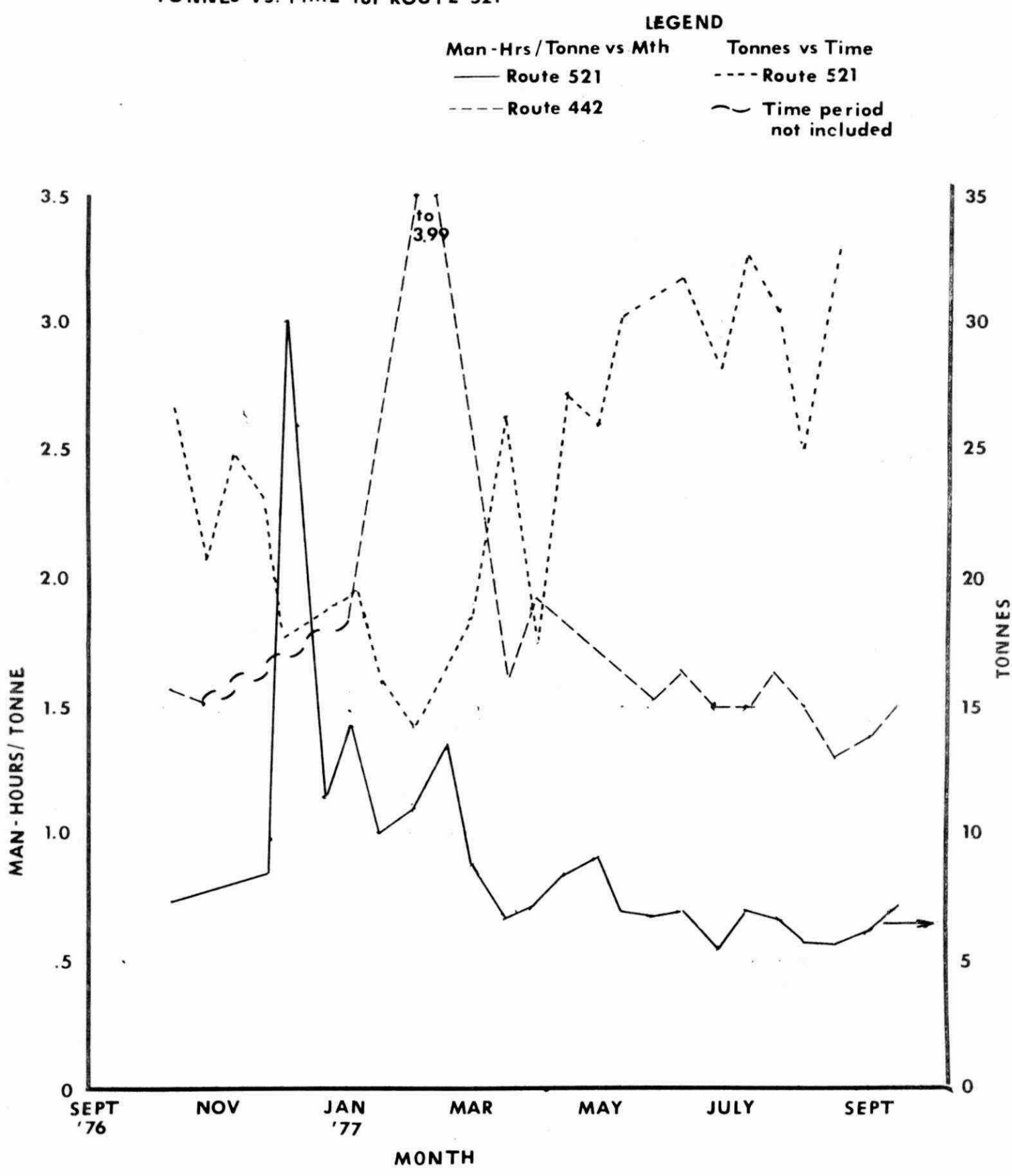
1. type of service, e.g. frequency, point of collection,
2. crew size,
3. method of trash handling, and
4. disposal method, e.g. landfill, transfer station, haul distance.

Consequently, the general conclusions of this study must be interpreted carefully by municipalities with collection systems that are dissimilar to that of the Municipality of Windsor.

In analyzing various collection methods, rigorous comparisons can only be made when the above-noted variables are eliminated. The use of time study techniques on the actual mechanics of collection should serve to yield "normalized" information on collection productivity. The following section presents the results of such time studies.

Figure 11

MAN-HOURS/TONNE VS. MONTH for ROUTES 521 & 442;
TONNES VS. TIME for ROUTE 521



B. Time Study Results

i) Observations

Time study data were obtained for the routes featuring mechanized tipping, mechanical collection, and normal collection. These surveys were carried out primarily to determine whether significant differences in collection times existed for the various systems studied. In addition, the time study data were used to assess system productivity; the National Commission on Productivity[5] recommends using "total tons collected per collection hour" as a productivity measure. In this context, collection hours represents time actually spent picking up and loading solid waste but excluding lunch and other breaks, haul time, unloading time, and any other non-collection time.

Time study data were obtained on several occasions for each system. These were subsequently analyzed both for individual study periods and by pooling all time study data for a particular system. During these studies, time spent on actual collection of refuse was monitored as well as time spent in travelling from stop to stop. No account was taken of vehicular down-time, break times, or travel times to and from the transfer station. The pickup time study data reflected only the time spent in actual

picking up of refuse, depositing it in a collection vehicle, and returning the container to curbside.

The time study data for both pickup and travel are shown in Appendix B, Tables 1, 2, and 3. Results from separate surveys were statistically analyzed both individually and as a "pooled" sample. The following discussion and calculations pertain to the results of the "pooled" samples.

A review of the pooled results for each collection system indicates:

1) There does not appear to be an appreciable difference in pickup times for the mechanical collection system or the control route.

2) Pickup times for the mechanized tipping system were greater than those for the other systems studied.

3) No appreciable difference was noted between travel times for any of the systems studied.

ii) Productivity Calculations

Collection productivity may also be calculated using mean pickup and travel times in conjunction with a kg per stop generation figure, i.e. tonnes per crew collection hour is then:

$$\frac{1}{(T_t + T_p)\text{sec/stop}} \times \frac{60\text{ sec}}{\text{min}} \times \frac{60\text{ min}}{\text{hr}} \times \frac{\text{kg}}{\text{stop}} \times \frac{1}{2000\text{kg/ton}}$$

where T_t = travel time between stops, seconds, and T_p = pickup time at each stop, seconds.

A summary of such productivity calculations is presented in Table 4. It must be noted that these productivity calculations include collection time as well as time spent driving or walking/riding on the route.

Although productivity measurements for waste collection systems are not routinely published, some reference data are found in the APWA's "Solid Waste Collection Practice"[7]. However, it is not clear whether these "Best Known" productivity parameters include route travel time in calculating productivity performance. In this case, best productivity for a one-man crew ranged from 1.7 to 2.0 tonnes collected per crew collection hour. For a two-man crew, productivity was 1.9 to 2.7 tonnes per crew collection hour or 0.95 to 1.35 tonnes per man hour. The productivity observed for the mechanical collection system studied (2.07 tonnes/man hour) compares very favourably with the published "Best Known Productivity Performance".

TABLE 4

PURE COLLECTION PRODUCTIVITY

Route	Pickup Time (sec)	Travel Time (sec)	Total Time/ Stop (sec)	kg/Stop	Metric Tons/ Crew Hour*	Metric Tons/ Man Hour*
Mechanical Collection (521)	24.2	14.5	38.7	22.3	2.07	2.07
Mechanized Tipping (526)	38.3	18.7	57.0	21.0	1.33	0.66
Control	21.5	17.5	39.0	18.7	1.73	0.86

* Metric Tons x 1.1 = British Tons

For a realistic comparison of productivities, performance of the one-man mechanical collection system should be directly compared to that of a conventional side loader with a one-man crew. Such idealized control data were not obtained.

The most significant aspect of Table 4 is that collection times for the two-man control route and for the mechanical collection route are virtually identical. Obviously then, improved collection productivity stems solely from a reduction in the labour component of collection. For widespread implementation, this saving in labour expenditure must be greater than equipment amortization costs and mechanical collection maintenance costs.

It should be feasible to optimize collection route sizes using the productivity information of Table 4, a distribution profile of time study results, could also result in improved collection productivity.

C. Operating Experience

The major operational concern experienced in the mechanical collection study was the downtime encountered with the collection unit. Total downtime throughout the entire study was approximately 65 hours with two particular collection periods accounting for 31.5 hours of this total. The 65 hour downtime total represents approximately 10 percent of the time that the collection

unit was in operation. The downtime attributable to the mechanical collection unit as opposed to the collection vehicle was 52.5 hours. Most of this downtime resulted from malfunctioning of the hydraulic system serving the mechanical collection unit.

Total maintenance costs for the mechanical collection unit were $1200 with $100 being spent on replacement parts and the remainder on repair labour.

The above-noted downtime and maintenance costs indicate the need for considerable hydraulic maintenance capability for the mechanical collection system. This could possibly limit the potential application of such a system to larger communities with extensive repair and maintenance facilities. There was no indication that downtime of the unit diminished as the study progressed.

Very little downtime was experienced with the mechanized tipping collection units. Throughout the study, total downtime was 8.0 hours and total maintenance costs $285, with parts accounting for $30 of this total.

In general, both container sizes were found to be adequate for both the mechanized tipping and mechanical collection studies. Approximately three percent of all of the stops serviced by the innovative collection systems requested additional containers. Each of these requests was for a dwelling housing two or more families.

Although the entire study had over 1000 small containers in use, only one container was stolen and fires damaged two others. No mechanical damage through usage was experienced to any of the containers involved in the study.

As indicated earlier, home owners did not perceive any problems during winter collection with either of the innovative collection systems. However, the Public Works Department did experience hydraulic problems during winter operation. These problems were most pronounced with the mechanical collection unit and were overcome by inside parking of the vehicle overnight.

D. Feasibility

The following section reviews the costs and benefits for hypothetical implementation of a mechanical collection system in a large community. Although the assumptions upon which the analyses are made are identified, it is recognized that all possible factors affecting the cost benefits analysis are not included. The following is merely an attempt to gauge the significance of the quantified cost savings observed through the use of mechanical collection.

It must be noted that mechanical collection is not applicable through any entire community. The mechanical collection system studied is not suitable for high density areas or commercial or industrial activities. The system cannot be considered an alternative to the use of refuse containers serviced by front-end loaders, luggers, or roll-offs.

1. System Implementation Costs

Assumptions

- mechanical collection serves residential areas only, once a week collection,
- population served by mechanical collection - 200,000,
- residential refuse generated at 2.2 lb/capita/day, 220 ton/day (7-day week), 200 tonnes/day (7-day week), 280 tonnes/day (5-day week),
- at 3.3 people per household, 61,000 stops,
- collection productivity and costs similar to those observed in this study
- one vehicle services 600 stop/day, 3000 stop/week; with 20 percent standby, a total of 24 vehicles is required,
- conventional collection services 500 stop/day, thus requiring a total of 30 conventional vehicles (two man crew) with the same 20 percent standby provision,
- crew foreman requirements not included in assessment,
- increased capital cost for mechanical collection fleet is $200,000; depreciated over 5 years at 10 percent yields annual cost of $53,000,
- total maintenance costs for reduced fleet equal to those for conventional fleet,
- container cost @ $90 is $5,490,000; annual cost to service container debt amortized over 10 years at 10 percent is $894,000,
- total additional cost for mechanical collection is $947,000 per year.

2. Operating Savings Using Mechanical Collection

Based on the results of this study, several methods may be used to calculate anticipated savings in operating costs using a mechanical collection system.

Observed collection costs for the mechanical system were $15.65/tonne with the control costs being $22.12/tonne for a net saving of $6.47/tonne. For our hypothetical case study, annual savings are then $6.47 x 200 x 365 or $472,000/year. Note that in establishing system costs, a premium charge was included for mechanical collection vehicle chargeback. The resulting system savings are then somewhat lower than those which would be expected from savings on labour costs alone.

Using the time study results (Table 4), a saving of .83 man hours/tonne collected was observed. For the case study, this would correspond to an annual savings of 0.83 x 200 x 365 or 60,600 man hours, approximately a staff of thirty people.

This figure is in agreement with the labour reduction anticipated in going from a 25 vehicle fleet (2-man collection crew) to a 20 vehicle fleet (1-man). At an annual wage and fringe benefit cost of $17,000/man, the labour saving would then be approximately $510,000/year.

For this particular case, it would appear reasonable to assume that labour savings would be in the order of $500,000/year. If salaries were assumed to escalate at a rate of 4 percent per year, then the mean labour savings over a ten-year period would be $600,000/year.

The improved productivity observed for the mechanical collection system could also be interpreted as indicating that one-man side-loading collection vehicles are more efficient than rear-loaders with two-man crews.

3. Implementation Potential

From the foregoing discussion, it is evident that the projected savings in labour are insufficient to cover the increase in equipment amortization costs, for the hypothetical case study using observed productivity data.

These observed productivity gains are highly specific to the Municipality of Windsor; they would likely vary for other municipalities depending on the nature of their current collection activities.

When assessing the potential of mechanical collection, some consideration must be given to the non-economic aspects of such systems. This study was not of sufficient scope to assess any possible effect on lost-time work injuries for the refuse collection occupation. However, the following section and Appendix C provide some insight into householder attitudes with respect to regular and innovative refuse collection.

E. Attitude Survey Results

A total of three attitude surveys were conducted on each of the mechanical collection and mechanized tipping routes. The surveys took place prior to implementing the study, approximately half-way through the study, and six weeks after the containers were collected upon project completion. Survey questions and associated percent responses are presented in Appendix C.

In general, the survey questions and responses are self-explanatory although a few comments are warranted.

While 75 percent of the householders surveyed were in favour of innovative refuse collection, only 42 percent were willing to undertake the cost of the specialized refuse container.

All of the surveys confirmed that convenience and sanitation (litter and cleanliness) were of paramount importance to the householder.

A significant drop in the use of plastic bags for storing garbage was not observed.

CONCLUSIONS

For the conditions under which this full scale study of innovative collection took place at the Municipality of Windsor, the following conclusions can be made with respect to the system study.

1. Collection productivity, when measured in man hour/stop, man hour/tonne, or cost/tonne, was significantly increased by using mechanical collection as opposed to conventional collection using rear loaders and two-man crews. This improved productivity was also confirmed by time study results.

2. Mechanized tipping did not result in any improvement in collection productivity, as measured by any parameter.

3. Widespread implementation of mechanical collection requires high capital expenditure, mainly for the provision of specialized collection containers.

REFERENCES

1. Anon, "Solid Waste Systems", Vol 4, No 3, May/June, 1975, p 35.

2. Bartolotta, R. J., "Solid Wastes Management", Vol 18, No. 12, December, 1975, p 26.

3. Bartolotta, R. J. "Solid Wastes Management", Vol 19, No. 2, February, 1976, p 44.

4. Dils, M., "Solid Wastes Management, Vol 19, No 13, p 42.

5. American Public Works Association, Solid Waste Collection Practice, Slavik Printing Company, Chicago, Illinois, 1975.

6. Stearns, R. R., and Graeffe, J., "Solid Wastes Management", Vol 19, No 11, p 32.

7. APWA, Solid Waste Collection Practice, op cit, p 76.

APPENDIX A

APPENDIX A - PRODUCTIVITY DATA

TABLE 1: MECHANICAL COLLECTION

Route No. 521
No. of Stops: 534

Period	Man Hours	Tonnes	Cost	MH/Stop	MH/Tonne	Cost/Stop	Cost/Tonne
Oct 3 - Oct 16/76	19.5*	26.76	289.58	0.018	0.73	0.271	10.82
Oct 17-Oct 30	16.0*	20.77	232.14	0.015	0.77	0.217	11.18
Oct 31-Nov 13	20.0*	24.63	290.92	0.019	0.81	0.272	11.81
Nov 14-Nov 27	19.0*	22.63	355.61	0.018	0.84	0.333	15.71
Nov 28-Dec 11	54.8*	17.78	637.82	0.051	3.08	0.597	35.88
Dec 12-Dec 25	21.8*	19.05	361.34	0.020	1.14	0.338	18.97
Dec 26-Jan 8/77	28.0*	19.55	512.60	0.026	1.43	0.480	26.23
Jan 9-Jan 22	16.5*	16.14	301.34	0.015	1.02	0.282	18.67
Jan 23-Feb 5	16.0	14.24	271.52	0.015	1.12	0.254	19.07
Feb 6-Feb 19	18.0	13.24	307.86	0.017	1.36	0.288	23.25
Feb 20-Mar 5	16.0	18.46	271.52	0.015	0.87	0.254	14.71
Mar 6-Mar 19	18.0*	26.26	320.94	0.017	0.69	0.301	12.22
Mar 20-Apr 2	9.0*	12.56	182.10	0.008	0.72	0.171	14.50
Apr 3-Apr 16	23.0	27.30	435.81	0.022	0.84	0.408	15.96
Apr 17-Apr 30	23.0*	25.76	444.75	0.022	0.89	0.416	17.27
May 1-May 14	21.5*	30.25	450.41	0.020	0.71	0.422	14.89
May 15-May 28	21.5	31.75	405.11	0.020	0.68	0.379	12.76
May 29-June 11	20.0	28.12	374.40	0.019	0.71	0.351	13.32
June 12-June 25	17.8	32.47	342.35	0.017	0.55	0.321	10.54
June 26-July 9	21.3	30.61	396.49	0.020	0.69	0.371	12.95
July 10-July 23	16.8*	25.12	317.05	0.016	0.67	0.297	12.62
July 24-Aug 6	19.0*	32.61	360.67	0.018	0.58	0.338	11.06
Aug 7-Aug 20	8.0	14.15	149.76	0.007	0.57	0.140	10.58
Aug 21-Sept 3	22.0*	34.69	399.02	0.021	0.63	0.374	11.50
Sept 4-Sept 17	20.0*	29.16	432.66	0.019	0.69	0.405	14.84
Sept 18-Oct 29 (688 stops)	73.3*	115.28	1431.69	0.018	0.64	0.346	12.42

NOTES:
1. All costs in dollars
2. * denotes overtime required
3. Period of Sept 18-Oct 29, 1977 used 10-hr, 4-day week
4. All weights in metric tons

APPENDIX A - PRODUCTIVITY DATA

TABLE 2: MIXED MECHANICAL COLLECTION

Route No. 523/524
No. of Stops: 294

Period	Man Hours	Tonnes	Cost	MH/Stop	MH/Tonne	Cost/Stop	Cost/Tonne
Oct 3-Oct 16/76	6.5	10.25	84.60	0.011	0.63	0.144	8.25
Oct 17-Oct 30	11.5	13.88	151.99	0.020	0.83	0.258	10.95
Oct 31-Nov 13	11.5	12.97	161.61	0.020	0.89	0.275	12.46
Nov 14-Nov 27	10.5	9.84	178.95	0.018	1.07	0.304	18.18
Nov 28-Dec 11	29.5*	8.89	352.44	0.050	3.32	0.599	39.65
Dec 12-Dec 25	7.0	7.30	120.30	0.012	0.96	0.205	16.48
Dec 26-Jan 8/77	22.0*	15.15	380.08	0.037	1.45	0.646	25.09
Jan 9-Jan 22	4.5	3.76	74.12	0.008	1.20	0.126	19.69
Jan 23-Feb 5	13.5	5.76	228.36	0.023	2.34	0.388	39.65
Feb 6-Feb 19	9.5	9.16	154.85	0.016	1.04	0.263	16.90

NOTES:

1. All costs in dollars
2. * denotes overtime required
3. All weights in metric tons

APPENDIX A - PRODUCTIVITY DATA

TABLE 3: MECHANIZED TIPPING

Route No. 526
No. of Stops: 442

Period	Man Hours	Tonnes	Cost	MH/Stop	MH/Tonne	Cost/Stop	Cost/Tonne
Oct 3-Oct 16/76	44.0	22.09	404.18	0.050	1.99	0.457	18.30
Oct 17-Oct 30	46.0	17.78	425.84	0.052	2.59	0.482	23.95
Oct 31-Nov 13	38.0	18.05	346.30	0.043	2.11	0.392	19.19
Nov 14-Nov 27	41.0	17.01	420.50	0.046	2.41	0.476	24.73
Nov 28-Dec 11	41.5	12.61	412.45	0.047	3.29	0.467	32.72
Dec 12-Dec 25	40.5	14.24	419.67	0.046	2.84	0.475	29.47
Dec 26-Jan 8/77	43.0	16.82	446.28	0.049	2.56	0.505	26.53
Jan 9-Jan 22	24.0	10.93	223.54	0.027	2.20	0.253	20.45
Jan 23-Feb 5	37.0	9.84	393.28	0.042	3.76	0.445	39.96
Feb 6-Feb 19	40.0	9.93	415.37	0.045	4.03	0.470	41.82
Feb 20-Mar 5	35.0	14.33	340.46	0.040	2.44	0.385	23.76
Mar 6-Mar 19	44.0	19.91	465.37	0.050	2.21	0.526	23.38
Mar 20-Apr 2	41.0	17.37	499.96	0.046	2.36	0.566	28.78
Apr 3-Apr 16	47.0	22.04	568.15	0.053	2.13	0.643	25.78
Apr 17-Apr 30	42.0	21.72	530.12	0.048	1.93	0.600	24.40
May 1-May 14	39.0	24.90	481.90	0.044	1.57	0.545	19.36
May 15-May 28	46.0	28.53	557.40	0.052	1.61	0.631	19.54
May 29-June 11	39.5	21.68	459.16	0.045	1.82	0.519	21.18
June 12-June 25	45.0	25.35	530.22	0.051	1.78	0.600	20.92
June 26-July 9	44.0	22.36	539.58	0.050	1.97	0.610	24.13
July 10-July 23	48.0*	22.90	468.87	0.054	2.10	0.530	20.47
July 24-Aug 6	25.5	14.92	333.60	0.029	1.71	0.377	22.36
Aug 7-Aug 20	41.0	23.81	484.84	0.046	1.72	0.548	20.36
Aug 21-Sept 3	37.5	20.50	373.15	0.042	1.83	0.422	18.20
Sept 4-Sept 17	47.0	14.78	619.70	0.053	3.18	0.701	41.92
Sept 18-Oct 29	146.0	83.74	1734.92	0.055	1.74	0.654	20.72

NOTES:
1. All costs in dollars
2. Overtime required in all periods except Aug 21-Sept 3, 1977
3. Period of Sept 18-Oct 29, 1977 used 10 hr, 4 day work week
4. All weights in metric tons

* Three man crew used for this period

APPENDIX A - PRODUCTIVITY DATA

TABLE 4: CONTROL ROUTE FOR MECHANIZED TIPPING

Route 433
No. of Stops: 460

Period	Man Hours	Tonnes	Cost	MH/Stop	MH/Tonne	Cost/Stop	Cost/Tonne
Oct 3-Oct 16/76	34.0	19.86	302.36	0.037	1.71	0.329	15.22
Oct 17-Oct 30	37.0	19.41	322.08	0.040	1.91	0.350	16.59
Oct 31-Nov 13	36.0	21.04	312.96	0.039	1.71	0.340	14.87
Nov 14-Nov 27	32.0	16.73	300.52	0.035	1.91	0.327	17.96
Nov 28-Dec 11	32.0	13.29	300.52	0.035	2.41	0.327	22.62
Dec 12-Dec 25	34.0	15.87	318.73	0.037	2.14	0.346	20.08
Dec 26-Jan 8/77	38.0	19.27	372.46	0.041	1.97	0.405	19.32
Jan 9-Jan 22	21.0	9.61	300.52	0.023	2.18	0.327	31.26
Jan 23-Feb 5	32.0	7.44	300.52	0.035	4.30	0.327	40.41
Feb 6-Feb 19	32.0	8.62	300.52	0.035	3.71	0.327	34.88
Feb 20-Mar 5	32.0	10.34	300.52	0.035	3.09	0.327	29.06
Mar 6-Mar 19	34.0	19.73	324.49	0.037	1.72	0.353	16.45
Mar 20-Apr 2	32.0	17.28	704.11	0.035	1.85	0.765	40.75
Apr 3-Apr 16	39.5	21.36	468.26	0.043	1.85	0.509	21.92
Apr 17-Apr 30	34.0	19.46	390.86	0.037	1.75	0.425	20.09
May 1-May 14	31.0	22.95	370.01	0.034	1.35	0.402	16.12
May 15-May 28	38.0	25.40	451.52	0.041	1.50	0.491	17.78
May 29-June 11	32.0	19.64	363.52	0.035	1.63	0.395	18.51
June 12-June 25	34.5	21.63	399.11	0.038	1.59	0.434	18.45
June 26-July 9	34.0	18.28	399.12	0.037	1.86	0.434	21.84
July 10-July 23	34.0	20.18	393.86	0.037	1.68	0.428	19.52
July 24-Aug 6	33.0	20.18	378.68	0.036	1.64	0.412	18.76
Aug 7-Aug 20	33.5	19.36	383.26	0.036	1.73	0.417	19.79
Aug 21-Sept 3	34.0	20.82	387.74	0.037	1.63	0.421	18.63
Sept 4-Sept 17	25.0	17.28	376.40	0.027	1.45	0.409	21.78

NOTES:
1. All costs in dollars
2. All weights in metric tons
3. Allotted collection time is 32.0 hr per reporting period

APPENDIX A - PRODUCTIVITY DATA

TABLE 5: CONTROL ROUTE FOR MECHANICAL COLLECTION (521)

Route 442
No. of Stops: 500

Period	Man Hours	Tonnes	Cost	MH/Stop	MH/Tonne	Cost/Stop	Cost/Tonne
Oct 3-Oct 16/76	16.0	10.20	139.76	0.016	1.57	0.140	13.70
Oct 17-Oct 30	20.0	13.29	186.92	0.020	1.51	0.187	14.07
Dec 26-Jan 8/77	46.5	25.03	558.55	0.046	1.86	0.559	22.31
Jan 9-Jan 22	36.0	13.38	577.17	0.036	2.69	0.577	43.14
Jan 23-Feb 5	32.0	8.03	301.24	0.032	3.99	0.301	37.53
Feb 6-Feb 19	32.0	10.25	300.52	0.032	3.12	0.301	29.32
Feb 20-Mar 5	32.0	12.11	300.52	0.032	2.64	0.301	24.82
Mar 6-Mar 19	34.0	20.86	318.86	0.034	1.63	0.319	15.28
Mar 20-Apr 2	32.0	16.55	733.65	0.032	1.93	0.734	44.32
Apr 3-Apr 16	40.0	22.40	472.84	0.040	1.79	0.473	21.11
Apr 17-Apr 30	36.0	20.82	421.18	0.036	1.73	0.421	20.23
May 1-May 14	36.0	22.36	424.18	0.036	1.61	0.424	18.97
May 15-May 28	41.0	26.44	582.58	0.041	1.55	0.583	22.03
May 29-June 11	34.0	20.77	387.98	0.034	1.64	0.388	18.68
June 12-June 25	33.5	22.27	389.48	0.034	1.50	0.389	17.49
June 26-July 9	35.5	23.58	430.94	0.036	1.51	0.431	18.27
July 10-July 23	33.0	20.23	378.68	0.033	1.63	0.379	18.72
July 24-Aug 6	16.0	10.57	181.76	0.016	1.51	0.182	17.20
Aug 7-Aug 20	32.0	24.72	363.52	0.032	1.29	0.364	14.71
Aug 21-Sept 3	31.5	22.99	357.46	0.032	1.37	0.357	15.55
Sept 4-Sept 17	37.0	24.58	421.08	0.037	1.51	0.421	17.13

NOTES:
1. All costs in dollars
2. All weights in metric tons
3. Allotted collection time is 32.0 hr per reporting period
4. Route used for testing satellite collection vehicle during Oct 31-Dec 25, 1976

APPENDIX A - PRODUCTIVITY DATA

TABLE 6: DIVISION AVERAGE

No. of Stops: N/A

Period	Man Hours	Tonnes	MH/Stop	MH/Tonne	Cost/Stop	Cost/Tonne
Oct 3-Oct 16/76	28.8	27.82	0.034	1.60	0.260	14.29
Oct 17-Oct 30	34.9	21.00	0.038	1.68	0.330	15.41
Oct 31-Nov 13	33.0	20.08	0.035	1.66	0.330	15.90
Nov 14-Nov 27	30.0	15.99	0.034	1.85	0.320	18.70
Nov 28-Dec 11	32.4	14.18	0.035	2.36	0.370	23.57
Dec 12-Dec 25	25.2	12.07	0.034	2.06	0.270	20.73
Dec 26-Jan 8/77	21.7	11.75	0.023	1.82	0.260	20.51
Jan 9-Jan 22	25.3	13.78	0.042	2.16	0.250	22.28
Jan 23-Feb 5	30.3	9.86	0.037	2.76	0.300	32.06
Feb 6-Feb 19	29.8	9.45	0.036	2.87	0.300	31.17
Feb 20-Mar 5	32.2	13.09	0.031	2.44	0.310	23.43
Mar 6-Mar 19	35.7	21.47	0.035	1.66	0.340	16.20
Mar 20-Apr 2	30.9	17.76	0.034	1.73	0.390	21.04
Apr 3-Apr 16	35.1	21.39	0.032	1.65	0.460	21.75
Apr 17-Apr 30	35.5	21.87	0.035	1.62	0.400	18.83
May 1-May 14	35.3	24.47	0.035	1.44	0.440	17.64
May 15-May 28	38.2	21.52	0.035	1.47	0.500	18.52
May 29-June 11	32.0	20.79	0.035	1.54	0.400	18.50
June 12-June 25	33.8	22.92	0.035	1.48	0.430	17.98
June 26-July 9	32.0	20.87	0.035	1.53	0.410	18.68
July 10-July 23	32.3	20.63	0.035	1.57	0.400	18.52
July 24-Aug 6	30.8	21.34	0.035	1.51	0.430	18.27
Aug 7-Aug 20	35.4	25.05	0.035	1.41	0.410	16.66
Aug 21-Sept 3	32.5	22.47	0.035	1.47	0.400	17.22
Sept 4-Sept 17	31.8	19.65	0.035	1.65	0.430	21.27
Sept 18-Oct 29	129.4	94.77	0.036	1.43	0.420	16.92

NOTES:
1. All costs in dollars
2. All weights in metric tons
3. Period of Sept 18-Oct 29, 1977 used 10 hr, 4 day work week

APPENDIX B

APPENDIX B - TIME STUDY RESULTS

TABLE 1: MECHANICAL COLLECTION

		8 Hr Day	8 Hr Day	10 Hr Day	Pooled Results
Pickup Times	No. of Samples	479	429	570	1478
	Mean	22.1	26.3	24.6	24.3
	Std Deviation	22.8	18.9	18.0	20.0
	90% Confidence Range	20.4-23.8	24.8-27.8	23.3-25.8	23.4-25.1
Travel Times	No. of Samples	472	425	552	1449
	Mean	17.6	11.6	14.1	14.5
	Std Deviation	24.5	9.4	15.2	17.7
	90% Confidence Range	15.8-19.5	10.9-12.4	13.0-15.1	13.7-15.3

Appendix B - TIME STUDY RESULTS

TABLE 2: MECHANIZED TIPPING

		8 Hr. Day	10 Hr. Day	Pooled Results
Pickup Times	No. of Samples	309	325	634
	Mean	38.9	37.7	38.3
	Std Deviation	25.1	22.1	23.6
	90% Confidence Range	36.6-41.3	35.7-39.7	36.8-39.8
Travel Times	No. of Samples	308	324	632
	Mean	20.9	16.7	18.7
	Std Deviation	14.9	11.4	13.3
	90% Confidence Range	19.5-22.2	15.6-17.7	17.8-19.6

APPENDIX B - TIME STUDY RESULTS

TABLE 3: MANUAL COLLECTION (CONTROL)

		8 Hr. Day	10 Hr. Day	Pooled Results
Pickup Times	No. of Samples	413	415	828
	Mean	23.5	19.5	21.5
	Std Deviation	20.6	21.5	21.1
	90% Confidence Range	21.8-25.2	17.8-21.3	20.3-22.7
Travel Times	No. of Samples	408	414	822
	Mean	15.4	19.5	17.5
	Std Deviation	15.1	24.0	20.2
	90% Confidence Range	14.1-16.6	17.6-21.5	16.3-18.6

APPENDIX C

APPENDIX C

PRE-SURVEY QUESTIONNAIRE

(all results expressed in percent)

	Mechanical Collection	Mechanized Tipping	Average
Sample Size	494	307	801
1. Can you estimate how much you spend on garbage containers (plastic bags, cans, etc.) per year?			
Less than $10	30.7	30.6	30.7
$10-20	21.8	52.8	33.7
$20-30	20.6	12.0	17.3
More than $30	26.7	3.6	17.8
No opinion	0.2	1.0	0.5
2. Can you estimate how much solid waste collection and disposal costs you per household per year?			
$10-20	5.5	2.9	4.5
$20-30	9.4	1.6	6.4
$30-40	9.8	2.6	7.0
$40-50	2.4	2.0	2.4
More than $50	13.6	2.6	9.4
No opinion	59.3	88.3	70.3
3. In general, how satisfied are you with the solid waste collection service you receive? Are you:			
Very satisfied	67.6	40.7	57.3
Somewhat satisfied	17.4	49.5	29.7
Not very satisfied	9.9	4.6	7.9
Not satisfied at all	5.1	1.0	3.5
No opinion	--	4.2	1.6
4. Have you any reason to complain to the City about your solid waste collection service here in your present neighbourhood?			
Yes	42.5	20.2	34.0
No	56.9	75.2	63.9
No opinion	0.6	4.6	2.1

	Mechanical Collection	Mechanized Tipping	Average
5. What is the nature of the complaint(s)?			
Litter (wind, pets, dumping)	75.2	12.9	61.0
Timing (reliability)	2.9	--	2.2
Noise	--	1.6	0.4
Damage to property	14.5	9.7	10.3
Other (specify)	11.4	75.8	26.1
6. Do you think that solid waste containers and container storage areas in your neighbourhood are:			
An eyesore	29.0	15.3	23.7
Unsightly	11.9	25.7	17.2
Unattractive	15.8	18.9	17.0
No problem at all	40.7	27.0	35.5
No opinion	2.6	13.1	6.6
7. Do you prefer to set out your waste in cans, plastic bags, paper bags, or something else?			
Cans	14.2	14.6	14.2
Plastic bags	53.0	41.4	48.0
Paper bags	1.8	--	1.1
Plastic bags in cans	27.2	41.7	32.3
Other (specify)	3.6	1.0	2.6
No preference	0.2	1.3	1.8
8. Reasons - rank in order of importance			
Convenience in handling	27.5	30.7	28.6
Sanitation	25.1	23.2	24.4
Economy	20.4	19.8	20.2
Sturdiness	20.6	17.6	19.6
Other (specify)	6.4	8.7	7.2

APPENDIX C

MID-TERM SURVEY QUESTIONNAIRE

(all results expressed in percent)

	Mechanical Collection	Mechanized Tipping	Average
Sample Size	297	248	545
1. Are you satisfied with the new solid waste collection service? Are you:			
Very satisfied	83.8	72.2	78.5
Somewhat satisfied	11.8	18.6	14.9
Not very satisfied	2.7	2.4	2.6
Not satisfied at all	1.7	2.0	1.8
No opinion	--	4.8	2.2
2. Have you any reason to complain about the new solid waste collection service?			
Yes	23.6	46.8	34.1
No	76.4	48.0	63.5
No opinion	--	5.2	2.4
3. What is the nature of the complaint(s)?			
Litter (wind, pets, dumping)	1.4	37.9	24.2
Timing (reliability)	45.7	2.6	18.8
Noise	--	--	--
Damage to property	--	--	--
Other (specify) Wind blowing containers over and smell	52.9	59.5	57.0
4. Do you think that the new solid waste containers and container storage areas in your neighbourhood are:			
Unsightly	1.0	--	0.5
Unattractive	2.7	1.6	2.2
No problem at all	42.4	10.9	28.1
Attractive	52.5	50.0	51.4
No opinion	1.4	37.5	17.8

	Mechanical Collection	Mechanized Tipping	Average
5. Would you prefer to set your waste in:			
Regular garbage cans	3.4	2.4	2.9
Plastic bags	2.0	1.6	1.8
Paper bags or boxes	0.3	0.8	0.6
New wheeled containers	84.2	66.1	76.0
No preference	9.8	29.1	18.5
Other (specify)	0.3	--	0.2
6. Rank in order of importance with regard to new wheeled container:			
Convenience in handling	26.2	22.9	24.4
Sanitation	27.4	23.4	25.4
Economy	22.8	21.4	21.6
Sturdiness	23.6	20.5	22.0
Other (specify)	--	11.8	6.6
7. The estimated life of the new wheeled container is 10 years. Would you be willing to pay $100 for the container by:			
Outright purchase	15.8	11.3	13.8
Spread over tax rate for 3 years	10.4	1.6	6.4
Spread over tax rate for 5 years	23.2	8.9	16.7
If not, how much would you pay?			
($0-50)	34.0	40.3	36.9
No opinion	16.6	37.9	26.2
8. Are you satisfied with the present colour (green)?			
Yes	97.6	81.9	90.4
No	1.7	1.2	1.5
No opinion	0.7	16.9	8.1
If no, which of the following would you prefer?			
White	20	--	12.5
Orange	20	--	12.5
Black	20	67	37.5
Yellow	--	33	12.5
Blue	20	--	12.5
Red	20	--	12.5

	Mechanical Collection	Mechanized Tipping	Average
9. Are you satisfied with the present size?			
Yes	90.9	70.2	81.5
No	8.8	19.7	13.7
No opinion	0.3	10.1	4.8
If no, Larger	80.8	91.8	88
Smaller	19.2	8.2	12
10. Any problems with winter usage?			
Yes	17.5	13.7	15.8
No	82.5	78.2	80.5
No opinion	--	8.1	3.7

If yes, specify: Moving container after storm or snow plowed in end of driveway.

APPENDIX C

POST COLLECTION SURVEY QUESTIONNAIRE

(all results expressed in percent)

	Mechanical Collection	Mechanized Tipping	Average
Sample Size	357	367	724
Owner	90.8	96.5	93.6
Tenant	8.1	3.3	5.7
Commercial	1.1	0.2	0.7
1. Do you prefer the regular collection methods now being used as compared to the wheeled container method?			
Yes	16.0	21.0	18.5
No	75.9	71.4	73.6
No opinion	8.1	7.6	7.9
2. What did you like about the wheeled container collection system?			
Convenience	37.5	40.1	38.8
Cleanliness	16.3	29.4	22.9
Appearance	8.0	5.7	6.9
Storage and Size	9.5	13.3	11.5
Keeps animals out	10.4	--	5.1
Economical	1.1	0.3	0.7
Everything	5.3	3.8	4.6
Nothing	8.1	4.4	6.2
No reply	3.7	3.0	3.3
3. What did you not like about the wheeled container?			
Tipping in the wind	30.3	2.5	16.2
Too large	3.1	6.5	4.8
Too small	5.0	2.7	3.9
Problems due to snow	5.3	8.2	6.8
Vandalism	0.3	--	0.1
Reliability of collection service	3.9	12.5	8.3
Odours, maggots	3.4	4.7	4.0
Other damage	--	0.8	0.4
Too expensive	4.5	0.5	2.5
Design or Road hazard	2.2	4.7	3.6
Everything	2.5	0.6	1.5
No reply	39.5	56.1	47.9

	Mechanical Collection	Mechanized Tipping	Average
4. What container(s) are you now using to set your garbage out in?			
Regular garbage cans	26.6	13.1	19.7
Plastic bags	36.1	43.9	40.1
Both of the above	26.0	41.1	33.7
Paper bags and/or boxes	0.6	1.4	1.0
Other	0.3	--	0.1
No preference	10.4	0.5	5.4
5. Can you estimate how much you are now spending on garbage containers (plastic bags, cans, etc.) per year since the return to regular collection?			
Less than $10	32.2	41.1	36.8
$10-20	34.2	26.2	30.1
$20-30	12.9	11.2	12.0
More than $30	5.0	14.4	9.8
No idea	15.7	7.1	11.3
6. The cost per capita of refuse collection and disposal is $12.18 while other services are:			
Police and Fire Protection $87.32 Education $418.01 Parks and Recreation $30.04			
In comparison, do you feel refuse collection and disposal are:			
High	15.7	3.8	9.7
Low	3.4	7.4	5.4
Reasonable	62.5	73.8	68.2
No opinion	18.4	15.0	16.7
7. If the City were to implement the wheeled container system, would you be willing to pay $100 for the container?			
Yes	37.2	47.1	42.3
No	51.3	47.4	49.3
No opinion	11.5	5.5	8.4
If yes,			
Outright purchase	25.9	62.1	46.3
Spread over tax rate for 3 years	2.2	18.4	11.3
Spread over tax rate for 5 years	29.6	10.9	19.1
No opinion	42.3	8.6	23.3

	Mechanical Collection	Mechanized Tipping	Average
8. If a separate paper collection system was implemented in your area, would you be agreeable to setting out your newsprint separately from your other garbage?			
Yes	82.4	89.1	85.8
No	15.4	9.5	12.4
No reply	2.2	1.4	1.8

APPENDIX D

Ontario

Ministry of the Environment

Hon. George A. Kerr, Q.C., Minister

Everett Biggs, Deputy Minister

GARBAGE COLLECTION

WHY ARE WE DOING THIS?

Garbage collection and disposal costs the taxpayers of Windsor $2.2 million every year, and collection costs are the largest single portion of that amount. This study investigates one way of reducing direct and indirect collection costs.

Additional potential benefits include:

- More convenience to the householder.
- Improved sanitation and hygiene.
- Reduced pet intrusion and blowing litter.
- Reduced personal injuries to collection personnel.
- A more attractive street on collection days

FOR ASSISTANCE ...

The City of Windsor, Department of Public Works is operating the experimental program. For more information, of for any problems during the study, call the Solid Waste Control Centre at 948-4143.

CITY OF WINDSOR 1854

DEPARTMENT OF PUBLIC WORKS

H. G. PAYNE, M.A., M.A.Sc., P.ENG.
COMMISSIONER OF WORKS

A NEW WAY

A NEW WAY TO PUT OUT THE GARBAGE

WHO'S INVOLVED?

For the next year, your household and 1,500 other homes in Windsor will be using a new type of garbage container, provided free as part of a study of advanced refuse collection systems.

The City of Windsor and the Ontario Ministry of the Environment are working together in a study of advanced refuse collection systems using two types of standard wheeled containers to develop cleaner, more efficient and more economical garbage handling systems.

THIS IS IMPORTANT!

ONCE THE STUDY IS UNDER WAY, THE CITY WILL NOT COLLECT GARBAGE PUT OUT IN NON-STANDARD CONTAINERS.

To give the new system a fair trial, all normal refuse must be put out in the new wheeled containers. The usual separate collection service for bulk refuse and discards will continue as before.

WHAT'S INVOLVED:

Single-family containers of two types are being studied. One type, holding 67 gallons of refuse, is emptied hydraulically into a two-man collection vehicle. The other, holding 75 gallons, is emptied by an automated arm on a one-man collection vehicle. This vehicle will also collect a number of 250-gallon containers being tested in a high density, multiple dwelling area.

You will be interviewed before, during and after the study. Your comments and your experience over the next year with the new systems will help determine the future of this system in Windsor.

WHEN DOES IT BEGIN?

A standard container will be delivered to your home with instructions for use during the week of September 27. Since this is a one-year study, these containers will be collected a year later and may or may not be replaced with new ones by the City. PLEASE DO NOT DISCARD YOUR PRESENT GARBAGE CONTAINERS. YOU MAY NEED THEM AGAIN IN A YEAR'S TIME.

HOW DOES IT WORK?

When your new container arrives, use it as you would any ordinary garbage can. You don't need any bags and containers for your garbage inside the new unit. There is a handle on the container so you can tilt it back and wheel it easily to the curb. The container should be left facing the road for efficient pickup by the collection vehicle's automated equipment.

The container is made of durable, stain and corrosion-resistant material. It is easily rinsed out with a garden hose.

THE CORPORATION OF THE

CITY OF WINDSOR

H. G. PAYNE, M.A., M.A.Sc., P.Eng.
COMMISSIONER OF WORKS

ROOM 302 CITY HALL
WINDSOR, ONTARIO
N9A 6S1

TELEPHONE 254-1611
AREA CODE 519

DEPARTMENT OF PUBLIC WORKS

September 20, 1976.

DEAR RESIDENT:

The Ontario Ministry of the Environment and the City of Windsor require your co-operation and assistance in studying an advanced refuse collection system which is expected to offer increased convenience and economy for both the homeowner and the municipality.

In the next few weeks your condominium will receive a plastic waste container provided free by Environment Ontario. This device will replace your current method of containing household waste for the next year.

Because full participation in this study area is essential to the efficient and effective evaluation of the new system, these containers must be used for all your normal refuse. Any other containers of waste will be left untouched by city collectors. The normal special pickups of bulky items will continue as usual.

During the upcoming months and after the study has been completed, you will be asked for your views of refuse collection service and the new system.

Your opinion will help the participating agencies decide if this system should be utilized throughout the city and in other communities in the province.

Enclosed you will find a brochure that outlines this system and its potential benefits both to you and the city.

If you have any problems or questions regarding the study, please call Mr. Jim Steele, Solid Wastes Superintendent at the Solid Wastes Control Centre at 948-4143.

Yours very truly,

H. G. Payne, P. Eng.,
Commissioner of Works.

/mg

THE CORPORATION OF THE

CITY OF WINDSOR

H. G. PAYNE, M.A., M.A.Sc., P.Eng.
COMMISSIONER OF WORKS

ROOM 302 CITY HALL
WINDSOR, ONTARIO
N9A 6S1

TELEPHONE 254-1611
AREA CODE 519

DEPARTMENT OF PUBLIC WORKS

September 27th, 1976.

TO THE HOUSEHOLDER:

Effective next week, your normal day of collection will be THURSDAY. Therefore, the first scheduled refuse collection utilizing the new plastic container you have just received will be on Thursday, OCTOBER 7th, 1976.

A public demonstration of the equipment being utilized to pick up your new refuse container will be held on Monday, October 4th, from 4 P.M. to 7 P.M. in the parking lot of Roseville Public School, 6265 Roseville Drive.

Yours very truly,

H. G. Payne, P. Eng.,
Commissioner of Works.

WECC/mg